WHAT IS CLAIMED IS:

1. A method for preventing seismic liquefaction of the ground, in such a built-up urbanized area where a loose fine grained layer vulnerable to seismic liquefaction is underlain with a soft cohesive layer which is liable to uneven settlement caused by lowering of groundwater table, comprises a couple of sequential stages described in the following paragraphs.

The first stage is to lower the groundwater table down to the bottom level of loose fine grained layer by pumping pore water out of it until all the pore voids of it are aerated being the groundwater thus pumped out made to flow down through the soft cohesive layer and further down into the deep granular layer underlying said soft cohesive layer while a proper amount of compressed air at the pressure suitably higher than the groundwater pressure at the top level of said deep granular layer supplied into said deep granular layer, with the effect that the uplift force of said compressed air supplied reciprocally with the groundwater counteracts the downward force caused by lowering groundwater table in said loose fine grained layer.

This prevents any uneven settlement harmful to buried utilities like gas pipes.

In the second stage, a suitable amount of tap-water which is made overly saturated with air dissolved in it and its pressure is regulated suitably higher than the initial groundwater pressure at the top level of soft cohesive layer (hereinafter called said tap-water) wherein an adequate dose of micro particles of silica or the like in selected particle size and chemically treated to be useful and harmless for the purpose of underground use and also with a dose of diffusing agent required for preventing aggregation of said micro particles (hereinafter called said mineral powder) is blended in a regulating tube.

Said tap-water is injected into the aerated pore voids of loose fine grained layer in a steady flow until said

pore voids are fully filled up with said tap-water.

Then, the supply water valve is closed to make the head level of said tap-water fall down to the initial groundwater level so as to form an air-mixed zone of countless tiny air bubbles in the pore water of loose fine grained layer. These bubbled out of said tap-water swarming around cores of micro particle of said mineral powder lower the saturation degree in it down to the level at which no seismic liquefaction takes place even at the time of a violent earthquake.

2. A method for preventing seismic liquefaction of ground, as defined in claim 1 using the required number of bored wells. The depth of each one of them is divided into a top well extending down through the loose fine grained layer, a middle well extending from the bottom end of the top well down through the soft cohesive layer and a bottom well extending from the bottom end of the middle well down into the deep granular layer.

Both of the top well and the bottom well are packed fully with permeable material being each one of them placed in a top permeable section and a deep permeable section, respectively, and the middle well packed fully with such impermeable material as bentonite paste being placed in middle impermeable section.

After the top permeable section is aerated and the groundwater pumped out of it is made to flow down into the deep granular layer reciprocally with the compressed air otherwise supplied making both of them combined said upward acting force, said tap-water is blended with said mineral powder. The pressure of the combined mix that is regulated through said regulating tube as it is pumped into the loose fine grained layer.

3. A method for preventing seismic liquefaction of ground as defined in claims 1 and/or 2 to bore a required number of large diameter holes for the top well by means of such a method of boring holes without disturbing the

ground surrounding the bored hole where casing rally be used. The holes for the middle well and the bottom well may be bored the diameter of these will be approximately half the diameter of the holes for said top well.

They can be bored by means of the boring equipment customarily used for boring deep well. Those bored holes for the top well are to be filled up with permeable material, for the middle well are to be filled up with such an impermeable material as bentonite paste and for the bottom well are to be filled up with permeable material.

4. A method for preventing seismic liquefaction of ground as defined in claims 2 and/or 3 to make it easier for the pressurized water percolating into the clogged pore voids formed in the deep granular layer surrounding the deep permeable section to form countless micro capillary tubes penetrated into the clogging of accumulated dusty particles drawn out together with the groundwater pumped out of loose fine grained layer.

This is done by blowing compressed air reciprocally with said pressurized water flow into said clogged pore voids.

5. A method for preventing seismic liquefaction of the ground as defined in claims 1, 2, 3 and/or 4, in an event said method for preventing seismic liquefaction of ground is to be applied inside of a specified range of area where close to each one of outside peripheries of said specified range of area, there are such underground utilities, buildings and the like liable to harmful uneven settlement caused by the lowering of groundwater table in the loose fine grained layer.

A longitudinal perforated pipe is built along each one of the side peripheries of said range of area. By forming a hardly-permeable barrier consist of countless micro air bubbles fed up out of said perforated pipe with downward opening perforation installed by means of such a

pipe-pushing machine used in small-diameter pipe pushing method or the like. Said hardly permeable barrier is formed by countless micro air bubbles blown up out of said downward opened perforation of the longitudinal perforated pipe and it is effective to minimize the harmful uneven settlement caused by the lowering of groundwater table in said loose fine grained layer.

6. A method for preventing seismic liquefaction of ground as defined in claims 1, 2, 3, 4 and/or 5 to minimize the amount of fine particles drawn out together with the groundwater flow pumped out of said loose fine grained layer by keeping the rate of flow not higher than a predetermined rate.

7. A method for preventing seismic liquefaction of ground as defined in claims 1, 2, 3, 4, 5 and/or 6 to prevent pumping out groundwater in excess of a predetermined minimum rate by interrupting the pumping of groundwater out of loose fine grained layer as soon as the flow-rate sensor placed inside said top well and linked electronically to the means driving said submerged pump detects a flow rate in excess of predetermined rate.

8. A method for preventing seismic liquefaction of ground as defined in claim 7 comprises providing an air compressor installed on the ground surface where the air-tight tank and an air compressor are connected each other with an air pipe inserted in between them with an air check valve for holding a reverse flow of overly compressed air whereas the air-tight tank connected with pipes to the submerged pumps installed in rows of top well through a main water pipe with a water-check valve inserted in between them.

A reverse flow main pipe extends down into the bottom well from the air-tight tank, a water main valve being inserted in between them.

During while the submerged pumps are operated, the

pumped out groundwater is pushed up into said air-tight tank and pressurized water is made to flow through the open main valve, the reverse flow main pipe down into the deep permeable section surrounding the bottom well until the means driving the submerged pumps interrupt its operation when the water-pressure sensor placed in the main water pipe linked electronically to the means driving submerged pumps detects the rise of pressure in excess of predetermined level.

The operation of submerged pumps is interrupted, closing the main valve of reverse flow main pipe so as to suspend the flow of pressurized water into the deep permeable section.

As soon as the pressure sensor placed in the air-tight tank linked to the driving means of air compressor detects the lowering of the pressure in said tank lower than predetermined level, the operation of air compressor is resumed to raise the pressure in said air-tight tank and the main valve is opened to force compressed air to blow out the clogging formed by accumulation of dusty particles in the layer surrounding the bottom well, thus removing the choking of said clogging. Then soon after the water-pressure sensor detects the rise of pressure in the main water pipe back to the predetermined level, the pumping groundwater out of the loose fine grained layer by submerged pumps is resumed and the flow of said pressurized water into the deep permeable section is resumed.

Thus the repeated cycles of pumping groundwater out of the loose fine grained layer and forcing the pumped out water flow down into the deep permeable section with intermittent blowing compressed air into the clogged pore voids of deep permeable section are made during while the first stage of dewatering the loose fine grained layer in top permeable section as defined in the first object of the present invention of a method for preventing seismic liquefaction of ground.

9. A method for preventing seismic liquefaction of ground as defined in claim 7 to prevent blowing excessive amount of compressed air into the deep granular layer surrounding the bottom well by interrupting the driving air compressor to suspend blowing compressed air soon after the flow-rate meter linked electronically to the means driving the air compressor detects the rise of flow-rate in excess of the predetermined rate.

Countless micro capillary tubes are pierced into the clogging of dusty particles formed to raise the flow-rate of compressed air blowing into the bottom well to cause occurrence of nasty sewage odor or harmful oxygen-short air.

10. A method for preventing seismic liquefaction of ground as defined in claims 1, 2, 3, 4, 5, 6, 7, 8 and/or 9 to achieve applying the present method for preventing seismic liquefaction of ground without interrupting the function of such a public facility as a street by accommodating such buried pipes as the main water pipe, reverse flow main water pipe, supply water pipes and the like laying within the periphery of area for executing the method of the present invention in each one of the side ditch laying along each side of the roadway and the cross ditch of the roadway every ditch being covered with a cover board while by making such a equipment on the ground surface as an air-tight tank, an air compressor small and low headed mounted on a trolley for the freedom of movement for adapting the use in densely built-up urban areas where there is a low head clearance placed on the loose fine grained ground.